The Effect of Ambient Air Pollution on Human Health

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Abstract: The article presents the important issues of the negative effects of ambient (outdoor) air pollution on human health. The focus is on 4 common pollutants: particulate matter, ground-level ozone, nitrogen oxides and sulphur dioxide, and their significant health effects mainly on human respiratory and cardiovascular system even at levels once considered safe.

Key words: ambient air pollution, pollutants, human health, susceptible groups of population, air quality guidelines

1 Introduction

One of the fundamental preconditions of our health is clean air of acceptable quality. However, air pollution poses a major threat to health locally, nationally and worldwide. Exposure to many pollutants in air presents major burden of disease. According to the World Health Organization ("WHO"), the burden of disease due to air pollution is more than 370.000 premature deaths each year in Europe and a shorter life expectancy in average of 9 months; this can be attributed to the impacts of ambient (outdoor) air pollution. The most exposed groups are children, elderly and people with cardio respiratory health problems.

Air pollution is caused by physical, chemical or biological substance which, by itself or through a chemical reaction, modifies the natural properties of the atmosphere and can damage human health and/or the environment [1]. Air pollution must be considered as a local as well as a transboundary problem since emissions from one region or country can travel major distances in the atmosphere to another country. Single common pollutants recognized by WHO that cause serious damage to ecosystems, materials and human health, are nitrogen oxides (NOx), airborne particulate matter ("PM"), ground level ozone, sulphur dioxide (SO₂) and ammonia (NH₃). In addition, there are also a number of other toxic air pollutants that are of a public health concern [2]. Ground level ozone and particulate matter have been recognized as the most critical for human heath, ranging from minor effects on the respiratory system, to decreased lung function, chronic bronchitis, asthma, reduced life expectancy and death. Other impacts of air pollution of a major concern are acidification (acid

deposits that damage forests, rivers and other ecosystems), eutrophication due to excess input of nitrogen nutrients into land-based and aquatic ecosystems, leading also to loss of biodiversity, and material damage due to acidification and particulates [3].

The growing awareness of the need for clean air has been recognized in the past decades and action has been taken at national and EU level. EU level action is focusing on establishing minimum quality standards for ambient air and tackling other environmental issues, such as acid rain. Polluting emissions from industrial and mobile sources have been reduced and fuel quality improved. However, despite notable improvements, threatening air pollution impacts still persist. Therefore, the EU has issued guidelines, strategies and action programmes, find among which we can Community's 6th Environmental Action Programme: "Environment 2010: Our future, our choice", covering 7 Thematic Strategies, which represent the next generation of environmental policy in Europe.

Recent studies suggest that ambient air pollution is still a considerable threat to human health in Europe and worldwide; current standards are set too high and the legislation is insufficient. The aim of this article is to give special attention to more susceptible population groups, which are strongly affected by negative consequences of air pollution; furthermore, to present the negative effects of air pollution on human heath in general, focusing on four common air pollutants, elaborating each one of them separately: particulate matter, ground ozone, nitrogen dioxide and sulphur dioxide.

2 Air pollution and population groups at high risk

Worldwide, air pollution is responsible for a number of health problems. The health effects caused by air pollutants can range from subtle physiological and biochemical changes to problems with breathing, coughing, and aggravation of cardio respiratory conditions. Moreover, due to ambient air pollution, the effects on human health are far more reaching, but principally affect respiratory and cardiovascular system. Individual reactions to air pollutants mainly depend on the type of pollutant, degree and time of exposure, individual's health condition, genetics etc.

Within population there are numerous groups with higher risk for the effects of exposure to air pollution. These are human beings who are innately more susceptible to the effects of air pollutants, those who become more susceptible or those who are exposed to unusually large amounts of air pollutants [4].

Unborn children, infants and young children seem to be particularly sensitive groups. Children have increased exposure to air pollutants due to increased minute ventilation and increased levels of physical activity [5]. It has also been shown that lead is neurotoxic for infants. Moreover, the elderly, people with cardio respiratory diseases and socio economically deprived people are also groups that need special attention.

In Table 1 current WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide are presented.

Table 1: World Health Organisation Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, 2005 [6]

Pollutant	Air Quality Guideline	
PM2.5		
Annual mean	$10 \mu g/m^3$	
24-hour mean	$25 \mu g/m^3$	
PM10		
Annual mean	$20 \mu g/m^3$	
24-hour mean	$50 \mu\text{g/m}^3$	
Ozone		
8-hour mean	$100 \mu g/m^3$	
Nitrogen dioxide		
Annual mean	$40 \mu g/m^3$	
1-hour means	$200 \mu g/m^3$	
Sulphur dioxide		
24-hour mean	$20 \mu g/m^3$	
10-minute mea	an $500 \mu\text{g/m}^3$	

Both in adults and children carbon monoxide, for example, deteriorates oxygen transport. Some other pollutants have effects on health such as aggravation of asthma, respiratory tract illnesses, and deterioration of lung function. Specific pollutants and their negative impacts on human health are going to be elaborated more in detail in the following chapters.

3 Particulate Matter ("PM")

Particulate matter is recognized as one of the most damaging air pollutants to human health. The term itself is used to describe airborne mixture of solid and/or liquid particles of variable size, origin and composition. Mostly, classification by size is used, since size determines the transport and removal of particles from the air and their deposition within the respiratory systems. Based on size, particulate matter is divided into three groups: ultra fine, fine and coarse particles [4].

Coarse particles are particles with aerodynamic diameter smaller than 10 μ m ("PM₁₀"). Fine particles have aerodynamic diameter 2.5 μ m or less ("PM_{2.5}"). Fine particles are mostly emitted from combustion processes and from some industrial activities. They tend to penetrate deeply into the lung and may reach the alveolar region. Coarse particles include wind-blown dust from dirt roads or soil and may reach the upper part of the airways and lung and also alveoli in the case of forced breathing or damaged lung tissue [7].

Short-term exposure to particulate matter contributes to: respiratory symptoms, adverse effects on cardiovascular system, increase in medication usage, hospital admissions and mortality. The mechanism related to cardiac effects is probably related to dysfunctions in the cardiac autonomic nervous system and arrhythmias [8].

Effects related to long-term exposure include increase in chronic obstructive pulmonary disease and reduction in lung function in adults and children. There is also an estimated reduction in life expectancy for the population in the EU, which is 8.6 months in average [3]. Since particulate matters in ambient air have various sources they also have variable toxicity. Some epidemiological studies suggest that combustion sources are particularly important for health. The primary combustion particles have higher toxic potential since they are rich in transition metals, organic compounds and have high surface area. On the other hand, some other single components of the particulate matter mixture (example given ammonium salts, chlorides, nitrates, silicate clays) have been shown to have lower toxicity [4].

4 Ground-level Ozone

Ozone is a secondary pollutant since it is not emitted directly, but is usually formed when nitrogen oxides (NOx) and volatile organic compounds (VOCs) react in the presence of sunlight. Therefore, peaks of ozone concentration tend to be highest during summer and mid afternoon. Ozone is a powerful oxidant and when the total concentration of oxidants in the atmosphere is highest, ozone represents approximately 90% of the total concentration.

At ground level, ozone is harmful to human health and ecosystems. Short-term effects include lung inflammatory reactions and adverse effects on respiratory function. At long-term exposure, irritation of the eye can occur; also, people with chronic obstructive pulmonary disease, such as asthma or emphysema can experience shortness of breath, increased oxygen demand and reduced arterial oxygen concentration [9]. In adults, ozone may also cause respiratory airway inflammation and hyper reactivity, and worsening of pulmonary functions. Asthmatics are particularly a group of higher risk since there is a marked increase in asthmatic attacks when the concentration of ozone is greater than $500\mu g/m^3$.

Previously it was thought that only ozone peaks were important, but newer time-series studies have demonstrated linear relationship between day-today variations in ozone levels and health even at low exposure levels.

5 Nitrogen Oxides

Nitrogen oxides, which have an important role in air pollution and in reactions of atmospheric oxidants, include nitrogen oxide (NO) and nitrogen dioxide (NO₂). Nitrogen oxides are released into atmosphere after combustion of any material that contains nitrogen. In addition, nitrogen oxides are produced by high temperature combustion from nitrogen in air. The main outdoor sources of nitrogen oxides include gasoline-powered engines, diesel engines, and power plants.

Short-term effects of exposure to nitrogen dioxide can elicit airway allergic inflammatory reactions, increases in hospital admissions and mortality [4]. Experimental researches conducted on humans showed that the concentration of nitrogen dioxide over 500 μ g/m³ in one hour exposure in most cases elicits chest discomfort. Newer exposure studies of people with asthma have found that short-term exposures to nitrogen dioxide at levels as low as 50 μ g/m³ can elicit stronger allergic response after coming in contact with allergens [10].

In addition, nitrogen dioxide also contributes to global warming, to eutrophication, the formation of ground-level ozone and acid deposition [3]. The increased level of nitrogen oxides can be a marker for traffic-related emissions or combustion related pollution.

6 Sulphur Dioxide

Sulphur dioxide is emitted from combustion of oil and coal, in refinery of petroleum, in chemical and metallurgical industry. Sulphur dioxide worsens acid deposition and harms human health. Past studies have shown that increased concentrations can elicit dyspnoea (heavy breathing with associated discomfort) and eye irritation. Experiments with rats and sulphur dioxide exposure showed enhanced aging of the rats and pathohistologic changes in the heart, lungs and kidneys [9]. Recent studies in 12 Canadian cities have shown significant association between 24hour SO₂ levels and daily mortality at levels as low as 5 μ g/m³ [11]. Although levels of sulphur dioxide have been decreasing dramatically in the recent vears due to the adoption of control measures, high concentrations of sulphur dioxide can still be found near major sources such as large industrial facilities and coal-fired power plants. In Slovenia, for example, such areas are in the proximity of coalfired power plant Trbovlje and Sostanj [12].

7 Other Ambient Air Pollutants

Several thousands chemicals are used for commercial purposes and many of them are released into air through combustion in motor vehicles and industrial facilities or other sources. Besides aforementioned sulphur dioxide emissions from coal-fired power plants another air pollutant is emitted - mercury. It is has been classified as a developmental neurotoxicant and as a moderately persistent pollutant which accumulates in soil and surface waters. Some other persistent air pollutants are lead and dioxins which degrade very slowly or not at all. They bio accumulate in air, water, soil and food, consequently in animals and humans. Lead accumulates mainly in brain and liver and causes neurological disorders [9].

Ammonia (NH3) is emitted mainly from animal wastes and due to the use of fertilisers in agriculture. It contributes, along with sulphur dioxide and nitrogen oxides, to acid deposition and to the formation of secondary particles. An important group is also volatile organic compounds, which are emitted to atmosphere from natural sources and through the use of solvents, paints, in the storage of transport fuels and motor exhaust emissions. They are crucial for the formation of ground-level ozone with the effects on human health as already mentioned in the text.

Hazardous air pollutants ("HAP") represent 188 pollutants and chemical groups that cause or may cause cancer, birth defects, neurological and respiratory illnesses [13]. Current European air quality legislation also includes some of the HAPs, such as benzene, polycyclic aromatic hydrocarbons, heavy metals, cadmium, mercury, arsenic and nickel [14].

8 Conclusion

Ambient air pollution continues to threaten human health and the quality of life; additionally, it has significant effects on natural environment. The magnitude of these effects is undoubtedly of a very large scale, therefore, only the implementation of existing legislation without taking the necessary measures to tackle the issue of air pollution, is not a sensible option.

The quality of air influences the quality of life of people; what is more, it can severely damage human health. The most severe effects have been shown to occur in most susceptible individuals. Groups that need most attention are children, asthmatics and those with pre-existing diseases, because they are more susceptible to air pollution at lower pollutant levels. Children are also very vulnerable as their lung development continues until adolescence. In addition to these groups, low exposure levels for general population show tendency for chronic ill health effects.

Although evidence of exposure to different air pollutants and consequent health effects has increased markedly over the past years there are still large gaps in knowledge. Additional research is needed on toxicity of different components, biological mechanism of effects, and especially of effects on susceptible groups of population. Currently, levels of most dangerous pollutants such as ozone and particulates, remain unsafe and hazardous in many parts of the Europe and the world; also, current European legislation and air quality standards and guidelines may not be enough protective for the public. As the EU Thematic Strategy on Air Pollution states, "levels of air quality that do not give rise to significant negative impacts on, and risks to human health and the environment", need to be attained. This is a multicomplex problem and there is no easy solution; however, the efforts to ensure clean air for all

should comprise: inclusion of air quality in relevant decision-making processes, working with relevant agencies and public transport partners, strategies to inform the public of local air quality issues and implementation of traffic management measures.

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